INTEGRATION OF GIS TECHNOLOGY IN ADVANCED INTERNET. A NEW SETTING FOR REFLECTING ON URBAN MATTER

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1. INTRODUCTION

The Laboratory of Virtual Modelling of the City at the Centre of Policies for Land Development and Valuation at the Polytechnic University of Catalonia is taking part in some projects aimed at trying out improvements and applications of the information systems of geospatial data and models of 3D architecture, as an experience towards new study models of the city.

Research today is an important “asset” capable of advancing the development of systems which integrate information technology and 3d visualising applied to the field of architecture and urban knowledge. With the appearance of virtual reality technology compatible with the GIS of Internet, together with the advance in fast large capacity ways of communication, researchers are being provided with the basic infrastructure to begin building virtual cities which can recreate an interactive environment of simulation and analysis of urban places with authentic realism, which can at the same time integrate all the environmental parameters as a whole (physical, social and economic), which require urban planning.

Following this line, the Specific Research Centre of the “Universidad Politécnica de Cataluña” called “Centro de Política de Suelo y Valoraciones” (CPSV), has taken the initiative in creating the “Laboratorio de Modelización Virtual de la Ciudad” LMVC, (Laboratory of Virtual Modelling of the City), promoted by the departments of Architectonical Building 1, Graphic Expression in Architecture 1, and the support of the “Escuela Superior de Arquitectura de Barcelona” ETSAB. The LMVC focuses its research activity on the improvement and application of GIS technology and 3D in the field of planning, study and valuation of urban components, as well as the visualization of architectonic reality or new proposals for the city. The LMVC is also linked to the Virtual Reality Centre at the UPC, and develops interactive architectonic models to be tried out by “immersion” at the installations of the CRV such as the CAVE.

The fundamental aim of the “Laboratorio de Modelización Virtual de la Ciudad” (LMVC), is to face up to the challenge of the information and knowledge era with a new boost from the university, aimed at reinforcing and improving current technological infrastructure and consolidating trans-disciplinary research teams focussed on the study and improvement of GIS and 3D applications towards the creation of optimum models of the virtual city. It also acts as a study and experimentation centre for universities and firms, aiming at extending and spreading this new culture in the social, professional and university fields.

The term Virtual City is alluded to on the web world today on many occasions, as a digital representation of urban localities (real or in project). Often the metaphor of the city as a visual interface to information resources is used, that is, the physical basis of streets, buildings, public spaces which respond to a spatial structure known by the citizens, is used
by suppliers of contents, as a interface where certain types of information on property, resources and services.

The crucial subject is the progress made in the integration of VR virtual reality technology with spatial databases, such as those held by GIS, which is very effective in urban simulation needed by planners. Following this line, the pioneer project - Virtual London - embarks on a path towards work prototypes which match the VR format with GIS Internet technology (Batty et al 1988), thereby establishing a new horizon in the spatial analysis of urban environment.

A new study universe is opening up, the importance of being able to integrate virtual models in 3d, images and contents in a relational system is essential to give an answer to all interrelated questions which need solving in a planning process. To have sound knowledge about a specific urban area, the quality of its buildings, the uses of its land, economical activities, inhabitants, mobility flow, aspects of public spaces, main needs or deficiencies (regarding installations and services), are among others key matters.

The Laboratory of Virtual Modelling of the City is carrying out a group of projects aimed at describing and building representative models of urban reality. The use of models is one of the basic features in the development of scientific research, in all kinds of disciplines. Models are a representation of reality which reduce or suppress certain properties to concentrate on others which are of interest to analyse as regards certain objectives. This simplification and abstraction are often hierarchical: models are built on simpler models which incorporate different basic properties.

2. GEOGRAPHIC INFORMATION SYSTEMS.

In the field of Geographic Information Systems a profile of models relative to the urban analysis and evaluation in GIS has been developed. This brings a new methodology in the analysis of urban structure, on the basis of techniques of spatial analysis of the GIS and factorial statistical techniques applied to the various bases of urban information handled by a local body. Interrelated links are set up between graphic reference entities and the contents are structured so that the interacting physical, organic and functional components which give rise to a particular urban scenario is given shape. The projects which are carried out go into the spatial context in greater depth as a differentiating element of urban structure taking into account perceptive and environmental criteria, studying and redefining aspects which contribute to urban quality. The result contributes a geospatial reading to physical, social and functional aspects of the city, such as centrality as an intensification of certain activities, the availability of land use, accessibility or proximity to the centre, interconnection with other points of the city, urban morphology understood as density, occupation of land and the characteristics of buildings, housing, their age .......
Fig. 1 Shows some variables of urban differentiation at a level of block such as 1. Uses of land: commercial intensity; 2. Morphology: size of site; 3. Land occupation per block; 4. System of installations: proximity to cultural installation; 5. Zones for urban development per block; 6. System of interconnection between district: Sant Josep.

Fig. 2 Shows a map of the residential attractiveness of Barcelona according to the opinion of non-residents who evaluate the uses, general characteristics, environmental quality, quality of architecture, safety ....
Models have also been made in **GIS for the environmental evaluation of the city** which try to set up guidelines, techniques and procedures aimed at presenting the contribution of the economic analysis to the appraisal of some relevant aspects of the environmental quality of the city, using the software of GIS tools. Following this line is the research project classified in LIFE 98 which aims at establishing a methodology and models relative to the analysis-cost-profit of external environmental factors (elaborated on the base of GIS tools). Negative effects are analysed (atmospheric pollution, noise, deterioration and obsolescence of the city buildings...) and positive ones (proximity to symbolic or centralized buildings, diversity and qualification of uses, services, characteristics of the population...) among other factors which affect the formation and structuring of urban values.

In a parallel way a **GIS for the evaluation of the tertiary axes of the city** has been carried out, based on information from the Land Registry and from the Economic Activity Tax census, among other sources. A methodology and a procedure of analysis on a system of geographic information is carried out which permits the study and assessment of the layout of the urban tertiary of Barcelona, highlighting the most representative axes, the prime zones, where the most emblematic buildings and those which offer optimum building characteristics are - the value of the property according to selling or renting prices as well as its land value relative to the urban position it occupies.

Summarizing, the procedure consists of establishing the configuration of the main tertiary axes which are deduced from the analysis of the concentration of areas of tertiary activity (from the “IAE” database) and office areas (land registry database), relative to each stretch of road and street facade.

- Classification of the economic activity by adding registers with a qualified tertiary profile,a).
- Cartographic demarcation of microzone stretches of street (on statistical municipal areas), which represent a homogeneous area,b).
- Referencing of the information on economical activity,c).
- Analysis and classification of microzone stretches of street - from greater to lesser level of density of tertiary activity,d).
- Adaptation stretches of street - Cadastral Zones. Analysis and classification of Cadastral stretches from greater to lesser level of tertiary activity,e).
- Reclassification into three categories of tertiary importance,f).

**Fig. 3** Shows section b) Cartographic demarcation and c) Referencing of information d) Analysis and classification of microzone stretches of street - from greater to lesser level of density of tertiary activity.
With this, a detailed description of the exceptional concentration of uses and activities located in the city is established, aimed at evaluating the economic impact of being situated in certain urban locations according to market information (Fig. 4). The study of individualized values of the income from each piece of property, its capitalized value as a sale value on the market, allows us, with the application of the algorithm of residual value calculation, to establish the land value of specific sites, its added evaluation by axes which through the application of market simulation models using hedonic models, will permit a demarcation of the general structure of values (See Fig. 5).

![Fig. 4 Market information](image)

Similarly a System of information on Urban heritage has been carried out on buildings of artistic interest which have been catalogued by the Barcelona City Council. The system which has been developed enables one to consult the characteristics of the buildings, how much they are protected and the elements protected: facade, structure, etc.. Also how much is allowed to be done or refurbished and the elements of special protection. The geographic interrelationship enables one to establish hypotheses of improvement in the use and conservation of these properties according to their position in the urban context, their most developed uses and activities in their immediate surroundings, orientate their re-use according to the needs or requirements of installations for collective use among others. (Fig. 6).
office activity

Fig. 6 System of information on Urban heritage

A wide field of research is thus opened up around the use GIS as management systems of geospatial information of exceptional relevance in the transformation processes of the city. The complex articulation of the necessary urban development instruments, within Spain as in other places, when it is a question of acting on a consolidated building area, where properties are involved which have a volume of building with an activity which has to be completely transformed or disappear, wide resources are needed to gather together all the information, with sound management (so that it is viable in costs and time) and at the same time facilitate its previous visualization before carrying out the project.

The LMVC is carrying out a project for the municipal body of Barcelona known as “Proeixample” which consists of making a GIS for carrying out the transformation of the interiors of city blocks into green spaces. This proposal aims at incorporating a series of graphic and associated alphanumerical data which will allow the transformation process of inner areas of the city blocks in the “Ensanche” (urban expansion area) of Barcelona to be studied and carried out correctly. The new regulation for urban development requires that the inner courtyard area of the block which is one and a half times more than the depth of the building, should become a public or private green space. This has to be done with a certain order and according to a specific plan which has to be both effective and viable - an extremely complex matter (see Fig. 7).

Fig. 7 GIS for carrying out the transformation of the interiors of city blocks into green spaces
3. TOWARDS A NEW DIMENSION IN 3D

The approach of the research developed by the LMVC of Barcelona is to make the 3D simulation models of virtual reality of the city (VR) compatible with spatial analysis systems in GIS, with the aim of recreating present or future scenarios with an atmosphere of real and precise space, with analysis systems of visual, social, economic and functional impact of certain actions.

The first results of the Barcelona project which the LMVC (Monedero et altres 2001) has carried out has made it possible to construct a **architectonic model of Paseo de Gracia in 3D**, rich in nuances of the buildings, their mouldings, reliefs, pergolas, which emphasize the architectonic quality of this exceptional “street”. The model has been carried out on a mesh structure of the facade of each building to which the real texture of the materials is assigned, (See Fig. 8). This graphic model has been compiled in VMRL format in order to surf its space, recreating a setting with street furniture and other. (Fig. 9).

![Fig. 8 Model of the facade](image)

![Fig. 9 VMRL format](image)

Models of new urban proposals of great importance have also been done. An example of this is the **Forum 2004 sector**, with an extension of 150 Ha comprising 15 singular buildings, on land which has had totally new building development and equipped with complementary buildings. It is a question of trying out models where real buildings and new designs merge, looking for ways of visualising which will help to bring a vision of the result before the project is actually carried out. The resulting geometric model has also been compiled in VMRL to be explored in an interactive way. In this case it is hoped that the result
will serve as a guide for the events that will take place in Forum 2004, as a teaching tool as referent for dimension, places and the final scenario of the event. (See Fig. 10).

![Forum 2004](image)

**Fig. 10** Forum 2004 sector

A 3D model of the City Land Registry has been tried out, which will allow full interaction with systems of territorial information. There is a first view of the tridimensional model on which the facades are being applied (with raster imaging) which come from the architectonic model of Paseo de Gracia, and which in a second phase, will integrate the links with territorial databases. At the moment there are operational difficulties in the handling of large volumes of information in formats which are accepted by suppliers of data, as the current land registry database uses the plot of land as the graphic representation unit.

One very effective option - because of the speed it was carried out- has been the raising of an area of the historic city centre - the square **Fossar de les Moreres**. On this an element of sculpture was to be put up - a censer in memory of the victims of the 1714 rising. The use of digital cartography and the raising of the building was done quickly and then on the volumetrics the images of photographs of the facades are inserted as texture suitably treated with photogrammetric process of geometries and the texture or colour of the materials of the facade. On this textured three-dimensional model the censer was incorporated, with a great geometric definition of material and colour, which was of great use to corroborate the dimension of the element, material, colours and affinity with its surroundings among other aspects of analysis before it was put up (see fig. 11).
Progress is being made in the execution of a design for a Virtual City: a model of virtual reality for the comprehensive management of urban territory which has been put forward with the support of the “Mancomunidad de Municipios Metropolitanos”, the Barcelona City Council and other bodies. Research is being carried out into the construction of a virtual model of urban territory which is being developed for the city of Barcelona, on different scales or levels of resolution; a volumetric one to scale of the whole urban territory and another architectonic one in the case of some specifically pre-selected places.

This project aims at dealing with a realistic and precise tridimensional model of the built-up part of Barcelona, which allows interactive surfing - to travel through the various urban scenarios and the virtual re-creation of new proposals. The areas of Paseo de Grace and Forum 2004 have been chosen in order to carry out a more detailed visualization. The land registry cartography is used as a base, the built-on volume being raised as 3d polygons and associating the textures of the building facades as raster imaging. The virtual reality is modelled on VMRL language although its compilation reduces the visual precision of some aspects - which is being solved with some speed.

In this case, as with some tridimensional models of big cities which are being made internationally, the aim is to improve the realism of the building shape of the virtual city and the integration of useful information in the process of city planning. Some authors such as William Jepson (UCLA) points out - with his Virtual Model of Los Angeles - that the real power of the virtual city which emerges, is that it allows a simulation which includes - virtually - all the planning process - and can be seen by expert and layman alike. We have found that designers, architects, developers and consultants can identify real problems and remedy them with new developments long before the first hole is dug. (Jepson et al 1996).

However, it is not sufficient to have a virtual city model capable of reproducing with realism and precision the actual town or urban planning, the visualization of different alternatives of a place, to permit the layman to understand the implications of the suggested changes. (Bourdakis 1997). In the models dealing with large urban extensions it is proposed to incorporate spatial analysis applications which will make it possible to evaluate the social-economic impact in the simulation models. (Kirby et al. 1997); (ART+COM 1998).

4. NEW AREAS OF REFLECTION ON THE CITY.

All in all, the various delegates who act and move around the city and who are immersed in the determination of an town planning policy which permits clear objectives to be held regarding the construction of the city - and we should include all property developers, agents, town planners, geographers, economists, sociologists - and why not - the participation of citizens in the obtainment of city design rooted in social reality - everybody seems to agree in the need to incorporate the new technology as a necessary instrument. Towards the convergence of new study areas for the component parts of a city, so that we can progress towards a governance where it is possible to balance these
components and move forwards, as Gerardo Estevez, former mayor of Santiago de Composela, said in the last Ibero-American Congress on Town Planning (Zaragoza, October 2002).

There exists, therefore, a new way of thinking about the need for actions in the city - less illustrated and more connected to the mixture of values that are contributed by the transformation, conservation, regeneration of environments of creativity, with references to the city’s past. It is a question of orientating city growth, taking geographical, historic, economic, social, environmental and town planning factors into account. Creating tools which will permit town planning to be done rationally implies co-ordinating infrastructures, with the new developments, with the needs of citizens, which in some cases means establishing new points of reference in buildings or civic areas of urban relationship.

The spatial complexity involved in the running of a city is very wide and certain models are required to analyse and deal with matters, one by one, to transform or make evident the positive aspects of each action. The creation of scenarios as new ways of presenting designs makes it possible to incorporate a wider group of professionals to participate and make decisions as regards the city.

In most of the projects which we develop in the LMVC, the existence of channels of information, accessibility appears as a necessary conditions to strengthen the design - the more a project can be visited and shared by a wider group of people, the more interesting it is.

5. **TOWARDS STANDARD FORMATS AND ADVANCED CHANNELS OF COMMUNICATION.**

Following these lines the LMVC is taking part in two projects which mean a significant improvement in the development of new format integration tools for the standardization of data and results, with the infrastructure project of Spatial Data in Catalonia “Proyecto Infraestructura de Datos Espaciales de Cataluña (IDEC). As well as having the capacity of sharing geospatial data, this involves a transmission need which the new prototypes of advanced internet are able to contribute, as has been seen in the 12CAT project.

In the recently held Forum GIS 2002, organized by the “Instituto Cartográfico de Cataluña” (Cartographic Institute of Catalonia), some of the developments reached in the previously mentioned IDEC and 12CAT projects were presented.

5.1 **The IDEC project has come from the Local Government in Catalonia**

The IDEC include needs that are implicitly or explicitly evident in the sector. Specifically, the Secretariat of Telecommunications and Society of Information of the DURSI (Department d’Universitats, Recerca i Societat de la Informació), i the Institut Cartogràfic de Catalunya, are the two institutions which have co-operated in the creation and drive of the project.

Today the production of geospatial information affects different bodies and in each case it seems necessary to recur to cartographic and alphanumerical BdData documented through descriptive Metadata, which conform to the ISO / TC 211 - 19115 standard, which can be incorporated to the server of the Infraestructura de Datos espaciales de Cataluña (IDEC) in order for them to be made public, to be known about, consulted and easily located by the community of users, both public and private, both in a national and international sphere, as IDEC is connected to the global “clearing house” network of spatial data.

In the same way, and so that data generated in different projects can by widely used, transferred and consulted through Internet resources, by means of Web mapping
technology, these data are available in GML (Geographic Markup Language) format, according to OPEN GIS CONSORTIUM specifications, for the interoperability of spatial data.

The construction of geographic simulation models on the different aspects which occur in town planning, for example decisions on locations in economic activity sectors (types of activity, infrastructure, transport, services, property structures) among other factors which qualify (positively or negatively) in urban space.

5.2 i2CAT is a project for building an internet platform

i2CAT. - both experimental and pre-competitive, to promote the development of broadband Internet services and applications by communities of research and innovation in Catalonia, both publicly and privately, as well as the creation of broadband communication infrastructures by operators and firms in Catalonia., promoted by the Universidad Politecnica de Cataluña (Polytechnic University of Catalonia).

For the use of the GIGANET network prototype (see figure 12) a connection has been made within the framework of Forum GIS 2002 between the Server of videos located in the UPC and the ICC, where large size videos (500 Mg) were viewed. These were suitably codified into Mpk formats and shown to those present at a speed of 8Mbps, with complete synchronization as if it were a connexion on a local network.

6. CONCLUSIONS

There are study methods and procedures on the real urban situation which permit the establishing of differentiation criteria of the city based on data and information generated by the municipality itself (land registry, economic activity, census of population...), with the links of geo-referenced information bases new objectives can be undertaken regarding the description and visualization (with the creation of hyper maps) of urban space on different scales. The 3D visualization models, with their different models of more detailed or simply volumetric representation, are capable of presenting a meticulous vision of the real urban situation.

However, a greater effort is necessary in the sharing of information produced by different centres (land registry, town planning, local body, service company...) to improve quality and optimize creation and maintenance costs, as the promoters of the IDEC project have pointed out. New communication infrastructures can also help by giving impetus to a new form of links on the net.
This can bring about consolidation in the creation and distribution of basic information which currently is a significant obstacle, and also a move forwards in the study and management of the existing city. To carry out proposals for certain actions - where it is possible to integrate criteria on the preferences of the general public in specific cases. Or also of great interest for a wide range of property developers, users, etc......

In summary, it is necessary to create new environments for the study of "urban reality". Some on-going projects in the LMVC have been presented here, which are aimed at constituting a Virtual Reality environment in Barcelona. We will continue, in future meetings, to offer a vision of the shape that these new proposals are taking - which we have outlined in a simple form - incorporating in the future the methodological and technical parameters which shape these projects.

7. BIBLIOGRAPHICAL REFERENCES:
